



Reflections on the Window Wall

By Fiona Aldous, Wiss, Janney, Elster Associates, Inc.

The glazed aluminum window wall synonymous with high-rise, multi-family residential construction reflects a continuing trend toward transparency within the practice of architecture, more typical of its commercial office building context. Through the window walls' aesthetic association to curtain wall, it appears to have created for itself a cost-driven niche throughout major United States cities, yet clear performance criteria and comprehensive details are still needed to ensure a successful project.

MODERNIST ORIGINS

Original window wall compositions, which some could argue may be traced back to the early decades of Modernism, relied principally upon a “barrier” approach to resist rainwater penetration. However, as air and water leakage problems became systemic, the design of the window wall adopted similar principles to rain screen design, including secondary flashings, receptors and sub-sills, heelbeads in the glazing pocket, back-pans sealed to framing at opaque panels and internally-drained systems to overcome these issues.¹

Throughout the United States today, the Modern aesthetic has been adopted by designers of high-rise residential buildings. However, many construction documents lack informed criteria for window wall performance, including design pressure, air and water penetration resistance, and glazing systems coordinated with the structural and mechanical characteristics of the specific building design—all information critical in procuring and installing a system that will meet the expectations of the owner and end-user with regard to long term durability and performance.

INDUSTRY DEFINITION

Perhaps some of the confusion is due to the lack of a clear definition of a window wall. While industry guidelines can be useful in defining the general configuration of each system, performance definitions are less clear. Consider the following widely held definitions:

- Fenestration: Openings in a building wall, such as windows, skylights and glass doors designed to permit the passage of air, light or people.²
- Curtain Wall: Any building wall, of any material, which carries no superimposed vertical loads, i.e. any “non-bearing” wall.³
- Metal Curtain Wall: An exterior curtain wall which may consist entirely or principally of metal, or may be a combination of metal, glass and other surfacing materials supported by or within a metal framework.⁴
- Window Wall: A type of metal curtain wall installed between floors or between floor and roof and typically composed of vertical and horizontal framing members, containing operable sash or ventilators, fixed lites or opaque panels or any combination thereof.⁵

As the industry definition of window wall suggests “metal curtain wall”, it is not surprising that the term “window wall” is frequently misunderstood, even by those in the design and construction professions whose responsibility it is to properly design, specify and install these systems. To address this concern, it is critical to understand window wall fundamentals related to structure and resistance to uncontrolled air and water infiltration.



THE INFLUENCE OF STRUCTURE

The design, engineering and installation of a curtain wall, and the inter-relationship between the structure and the curtain wall, are typically well understood issues. This includes compensating for movement within the wall components themselves, relative movement between the components, and relative movement between the walls and building frame to which it is attached.⁶ In addition, movements caused by temperature changes, wind action, gravity forces and deformation and/or displacement of building frame must also be factored.⁷ To further reinforce the issue, AAMA states, “to disregard such movements in designing the wall is an urgent invitation to trouble.”⁸

The movement considerations outlined above extend without exception to the design and installation of window walls. However, as window walls typically incorporate pre-designed window products, along with the potential for less experienced installers and manufacturers migrating from the traditional residential market, the structural and movement considerations are often overlooked. Window “gateway” minimum requirements, such as size, may not equate to window wall openings—attachment and loading calculations may not be performed to guide installation and product choices, and deflection of the structure may not be accommodated in the window wall design.

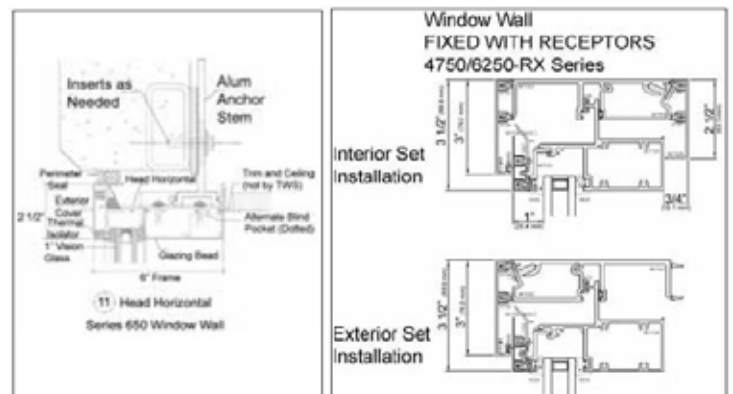
In determining the extent to which the structure will impact the window wall design, typically the fraction of a span $L/360$ is utilized as the deflection limit for concrete members; however it is suggested that the maximum expected deflection, being, “the sum of creep deflection from permanent loads, the ‘elastic’ deflection from transient loads, and the deflection effects of shrinkage and temperature change”⁹ must also be considered.

This is particularly critical with post-tensioned concrete slabs such as those typically utilized in high-rise residential construction, where allowable design live and dead load deflection at the center of continuous spans often results in 3/8 in. (9.7 mm) of movement, unless factors more stringent due to use/occupancy, or requirements of the initial design program are outlined. At cantilevered slabs such as those typically associated with projecting bay windows and window wall “stacks” this can be an important consideration (Figures 1.1 and 1.2).



Figures 1.1 and 1.2 - Cantilevered bays of window wall assemblies typical in high-rise residential construction.

A review of the structural design and the resulting deflection allowance, in addition to thermal and sealant compression characteristics will considerably impact the design of the window wall and interface conditions, including air barrier and sealant continuity without which, the performance of the entire exterior wall may be compromised. Properly specifying these issues, and including either a deflection header or movement anchor (Figures 2.1 and 2.2) as the basis of design is recommended in consultation with the structural engineer.



Figures 2.1* and 2.2** - Common deflection header or movement anchors provided by manufacturers of window wall assemblies. It is important to verify receptor joinery also accommodates movement if used.

* Detail Courtesy of www.oldcastleglass.com/ww_2.5_4.5-6_elevation.php

** Detail Courtesy of www.wausaustindow.com/resources/details/4750-6250%20RX.pdf



AIR AND WATER PENETRATION RESISTANCE

In part, the appeal of the window wall is derived from its operable and/or fixed lites or panels, and the available manufacturing diversity. However, to conceive this notion as straight forward is to recognize the conflicts, deal with the occasional whim and understand the cumulative intent of all the applicable industry standards, and ultimately define a clear performance specification based upon a practical, durable and sustainable approach! The air and water performance criteria established by the American Architectural Manufacturer’s Association (AAMA) (Figure 3), are generally accepted in the industry and can be used as a guide.

System and Industry Standard:	Water Penetration Resistance per ASTM E331, ASTM E547 and AAMA 501.1.	Air penetration Resistance per ASTM E283
AAMA/WDMA/CSA 101/I.S.2/A440-05		
R - Residential, LC - Light Commercial, C - Commercial, HC - Heavy Commercial	15% x *DP	75 Pa (1.57psf) and allow for 1.5 L/s.m2 (0.3 cfm/sf)
HC - Heavy Commercial (Compression seal & Fixed)	15% x *DP	300Pa (6.24 psf) and allow for 1.5 L/s.m2 (0.3 cfm/sf)
AW - Architectural Windows (Compression seal & Fixed)	20% x *DP	300Pa (6.24 psf) and allow for 0.5L/s.m2 (0.1 cfm/sf)
CW-DG-96-1 and AAMA MCWM-1-89		
Curtain Wall	20% x *DP	0.08 L/sm (0.06cfm/sf) of wall area plus per linear meter (foot) of crack for the operable window units (if any)

Figure 3 - Typical water and air performance criteria established by the American Architectural Manufacturer’s Association (AAMA) Note: For complete product listing of maximum allowable air leakage, see AAMA/WDMA/CSA 101/I.S.2/A440-05, Clause 5.3.2.1, Table 6, p.52 * DP = Design Pressure

However, when considering these standards as a guide it is also important to note:

- Typically, AAMA designated windows are tested as individual units. Rarely, if ever, are they tested in a window wall configuration that typically includes “ganged” or, less often, but more problematic, “stacked” mullions, receptor frames, and similar accessories—all components that significantly impact the overall performance.
- Maximum allowable air infiltration has traditionally been defined by ASTM E283 and AAMA/WDMA/CSA 101/I.S.2/A440-05, and are calculated based on square foot area or frame size (crack length). WDMA/AAMA/CSA Technical Joint Interpretation 06-05, dated 14 February 2007 stated: “the overall frame size is defined as the part of window fitting into rough opening.”¹⁰ As such, for a fixed and an operable unit utilizing a common subframe, the area

used to calculate net air infiltration through that assembly includes, by definition, the entire square foot area of the assembly, including the sub-frame (Figure 4), and not the individual lite as tested to gain AAMA-designation. This can fundamentally alter project-specific test results for a window wall assembly, often leading to confusion regarding what constitutes a “passing” grade during pre-construction mock-up and or field air infiltration testing. The standards, as currently written must be thoroughly understood by the design professional or construction specifier when crafting the specification.



Figure 4 - Although comprised of both fixed and operable lites, the area of the rough opening is used to determine air infiltration and not the individual lite. Isolating the individual lite during testing can prove useful in determining possible areas of excessive air leakage.

When specifying window wall assemblies utilizing multiple individual, AAMA-designated window units “ganged or stacked” together into a single floor-to-floor glazed area, it is recommended to establish water penetration resistance and allowable air leakage of the entire window wall assembly, and laboratory and/or field tests to validate performance. Note that AAMA allows a 33 percent reduction in pressure for field tests, which often results in testing that, may not replicate the actual design pressures to which the building is exposed. This information is critical to establish early in the project, rather than relying on the published performance test data or test standards for each of the window wall component parts.



INTEGRATED PERFORMANCE

As areas of window wall glazing often comprise whole exterior walls of residences, the designer should carefully and holistically evaluate the impacts of solar heat gain (SHG), glare, UV impact on interiors, Condensation Resistance Factor (CRF), Ufactor, and allowable air leakage relative to the HVAC design. A recent investigation of air tightness studies on commercial building envelopes identified tightening of the envelope in accordance with Air Barrier Association of America's (ABAA) recommended air leakage allowance of 0.02 L/s.m² at 75 Pa (0.04 cfm/sf at 0.3 in. H₂O) and "predicted potential annual heating and energy cost savings for these buildings ranged from 2 percent to 36 percent with the largest savings occurring in the heating-dominated climates."¹¹ High-rise residential building facades, incorporating window wall designs are moving towards emulating commercial building facades. However, consideration should be given to the internal residential energy-consuming functions which dramatically contrast with those of commercial buildings. Functions such as operable lites and associated higher air infiltration allowances, individually controlled HVAC units and less controllable relative humidity levels, and full height vision glazing (typically without sun shading devices) all inter-relate with the window wall. Hence, the widespread use of the window wall should be pondered in the context of energy-related performance factors which may not yet be fully appreciated.

DETAILS

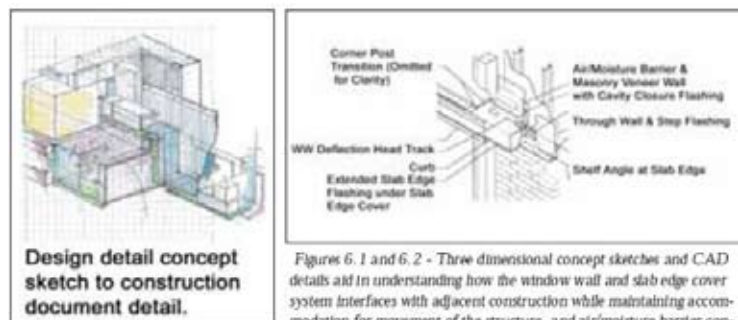
The cladding at the slab edge adds further complexity and is typically the weakest aspect of both the performance and design of the window wall (Figures 5.1 and 5.2).



Figures 5.1 and 5.2 - Problematic slab edge interfaces require special attention.

Not only must the slab edge cover accommodate the intricacies of the drainage of the window wall system, but also provide coordinated air and water resistance while addressing the concerns of thermal discontinuity such that it does not contribute to the development of condensation, meet the intent of the energy codes by installation of sufficient insulation and properly interface with adjacent construction. Three-dimensional drawings identifying conditions at slab edges (Figures 6.1 and 6.2), balconies, doors, secondary flashing and receptor systems, integration with adjacent wall (barrier or drainage) and/or roof systems, and accommodations for movement and air pressures associated with high-rise buildings, should all be considered in the overall detailing and specifying of the façade which incorporates window wall.

The window wall provides a modern cost and schedule-driven alternative to the curtain wall and although it is conceptually simple, the requirements for successful design, installation and long term durability are complex. The window wall requires thorough detailing of the slab edge condition by the designer and careful execution by the contractor. Overall, the window wall warrants careful and comprehensive consideration, and fundamentally clear performance criteria and detailing before inclusion in the design of highrise residential buildings.



Figures 6.1 and 6.2 - Three dimensional concept sketches and CAD details aid in understanding how the window wall and slab edge cover system interfaces with adjacent construction while maintaining accommodation for movement of the structure, and air/moisture barrier continuity.



POSTSCRIPT

Each structural or cladding component, adjacent to the window wall has the potential to impact the other. The coordination of construction tolerances referenced in the specifications and industry standards is equally as important as the design of details. A comprehensive review should be undertaken to ensure there is no negative impact on the window/sealant installation tolerances, or performance criteria. The review should include consideration of industry standards from American Concrete Institute, the Sealant, Waterproofing and Restoration Institute, and the American Architectural Manufacturer Association. Unless fully coordinated, the cumulative construction tolerances for formwork and slab placement may not agree with sealant design and window wall installation guidelines. The detailing of window wall must accommodate for the concrete structure between which it is inserted, and the perimeter sealant joint which typically seals the system to the adjacent air barrier component(s).

ABOUT THE AUTHOR

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CREDITS

This article was originally published Journal of Building Enclosure Design (JBED) An official publication of the Building Enclosure Technology and Environment Council (BETEC) of the National Institute of Building Sciences (NIBS). This BETEC biannual publication focuses on the latest developments in building energy conservation, security, and improved building envelope design and performance. It is distributed to all BETEC and other NIBS' councils' members. To subscribe at no cost, email your name and address to jbed@nibs.org.